

Exhibit A

Rim material: Glass Fiber / Epoxy matrix

1. Modulus of elasticity E_r in the hoop direction is calculated by Equation 5.3, shown in Attachment 1, which gives the E_r value of the composite based on the volume fraction of fiber and matrix.

$$E_r = E_c = V_f E_f + E_m (1 - V_f) \quad (5.3)$$

The volume fraction of fiber is known by the flywheel manufacturer using convention measurement techniques. In this example, the fiber volume fraction

$$V_f = 0.65$$

$$E_m = 413 \text{ ksi (from Attachment 2)}$$
$$= 2.85 \text{ GPa}$$

$$E_f = 72.45 \text{ GPa (from Attachment 3, page 2)}$$

$$E_r = 0.65 \times 72.45 + 2.85 \times (1 - 0.65)$$
$$= 48.09 \text{ GPa}$$

Rim liner material: Nylon 66

2. $E_l = 3.5 \text{ GPa}$ (from Attachment 4)

3. To obtain the ratio R_r of hoop modulus to density E_r/ρ_r , the density ρ_r is calculated from Equation (5.6) in Attachment 1 as follows:

$$\rho_r = \rho_c = V_f \rho_f + V_m \rho_m$$

$$= V_f \rho_f + (1 - V_f) \rho_m$$

$$\rho_f = 2.59 \text{ g/cm}^3 = 2.59 \times 10^3 \text{ Kg/m}^3 \text{ (from Attachment 3)}$$

$$V_f = 0.65$$

$$\rho_m = 1.161 \text{ g/cm}^3 = 1.161 \times 10^3 \text{ Kg/m}^3 \text{ (from attachment 2)}$$

$$\rho_r = 0.65 \times 2.59 \times 10^3 + (1 - 0.65) \times 1.161 \times 10^3$$
$$= 2.09 \times 10^3 \text{ Kg/m}^3$$

$$R_r = E_r/\rho_r$$

$$R_r = 48.09/(2.09 \times 10^3)$$
$$= 0.23 \text{ GPa m}^3/\text{Kg}$$

4. To obtain the ratio R_l of hoop modulus to density E_l/ρ_l , the density of the liner material can be obtained from open literature. In this case, the density of Nylon 66 is

$$\rho_l = 1.14 \times 10^3 \text{ Kg/m}^3 \quad \text{(from Attachment 4)}$$

$$R_l = E_l/\rho_l$$

$$= 3.5/(1.14 \times 10^3)$$

$$= 0.0031 \text{ GPa m}^3/\text{Kg}$$

Therefore, $R_r > R_l$